295608

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: RRG Clayton Chemical ` 0042192-95

Project: Capping Location: Sauget, Illinois

CALCULATION IDENTIFICATION

Calculation Ref. No.: ____________ No. Pages: 12
(Including calculation cover sheet)

Calculation Description:

CAP DRAINAGE LAYER HYDRAULICS

Design: A.Wesolowski Date: Oct10/06

Checked: R.Hoekstra Date:

RECORD OF REVISION

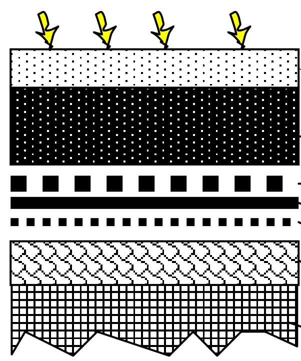
Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

CAP DRAINAGE LAYER HYDRAULICS

1. GEOCOMPOSITE DRAINAGE NET HYDRAULICS

1.1 Data input

-cap design:



- soil layer common fill permeability: k = 0.00001 cm/s (1×10^{-7} m/s)

- Slope gradient and length for selected critical paths:

  a) 5 % approx. 100 ft = 30 m

- optional 0.30 m thick sand drainage layer, typical permeability
  Ks = 0.03 cm/s = 0.0003 m/s

- reduction factors for drainage composite
  for intrusion RF_{in} = 1.5
  for creep RF_{cr} = 1.4
  for chemical clogging RF_{cc} = 1.2
  for biological clogging RF_{bc} = 1.6
  overall FS = 2
  Total Fs = 8

- criteria for Lateral Drainage for Final Cover Side Slope, Landfill Drainage System www.landfilldesign.com Unit Gradient Method (see attached).

1.2 Required transmissivity of the geocomposite Y_{ult}

Required (ultimate) geocomposite transmissivities for selected paths, (length, permeability and slope) have been calculated utilizing software program , Unit Gradient Method, (see attached).

a) Y ult = 0.00048 m^2/s for 5% slope

1.3 Available transmissivity of the geocomposite Y_{avail}

Available transmissivities for GSE Fabrinet 250 mil geocomposite product, according to attached manufacturer chart, Fig.A-6 for given (design) gradients and normal pressure of approximately 1000 psf at given cap design configuration.

a) Yavail = 0.001 m^2/s for 5% slope

1.4 Infiltration into sand drainage layer

Calculated infiltration flow, based on unit length along the slope Ls, given soil cover permeability Kcover and vertical seepage gradient = 1.

Qinfil = Ls x Kcover x 1 (m3/s per m width, per linear m)

Qinfil = 30m x 0.0000001 m/s x 1 = 0.000003 m3/s

1.5. Available sand drainage layer hydraulic capacity Qavail

Calculated available sand drainage layer hydraulic capacity, based on sand drainage layer permeability Ksand, vertical gradient slope i, and drainage layer cross-sectional area A.

Qsand = Ksand x i x A (m3/s per m width)

Qsand = 0.0003m/s x 0.05 x (0.3 m x 1 m) = 0.0000045 m3/s

1.6 Conclusion

a) Geocomposite drainage layer :

According to the results as shown in 1.2 and in 1.3, available transmissivities of GSE product are fully satisfactory, and no lateral drains are required. Flow generated from the cap infiltration will be fully contained within the drainage layer, providing that the cover soil has a permeability of 1×10^{-5} cm sec or less.

Y avail = 0.001 m^2/s > Y ult = 0.00048 m^2/s for 5% slope

Factor of safety, Fs = Yavail/Yult = 0.001/0.00048 = 2.08

(including previously applied factors for clogging as in part 1.1 on page 2)

b) Optional sand drainage layer:

According to the results as shown in part 1.4 and in 1.5, no lateral/relief drain will be required.
Flow generated from the cap infiltration will be fully contained within 0.3 m of the sand drainage layer, providing that the cover soil material and sand material will have permeability as assumed.

However factor of safety is only :

Fs = Qsand/ Qinfilt = 0.0000045 /0.0000030 = 1.5
(not inculing consideration for clogging)

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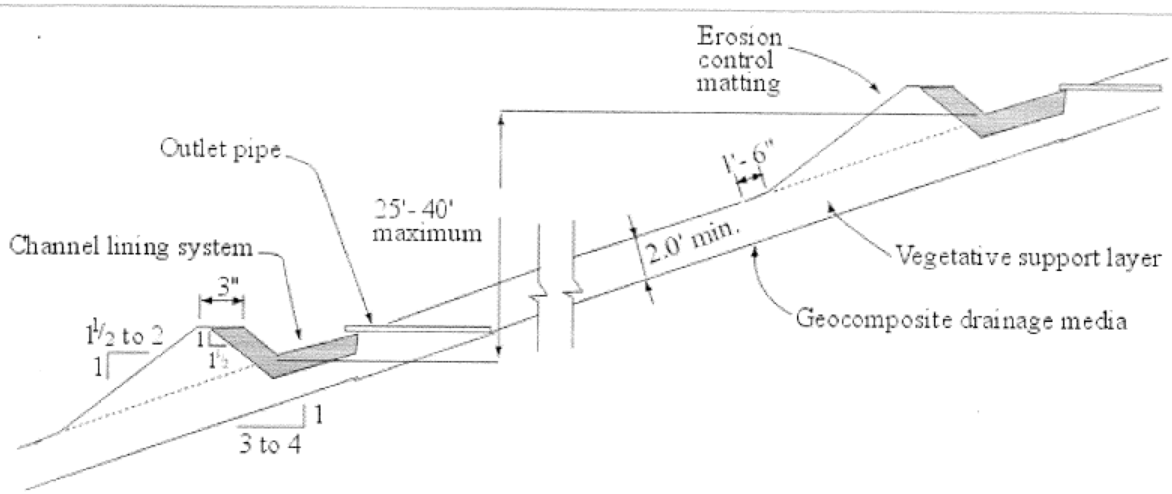
Unit Gradient Method - Design Calculator

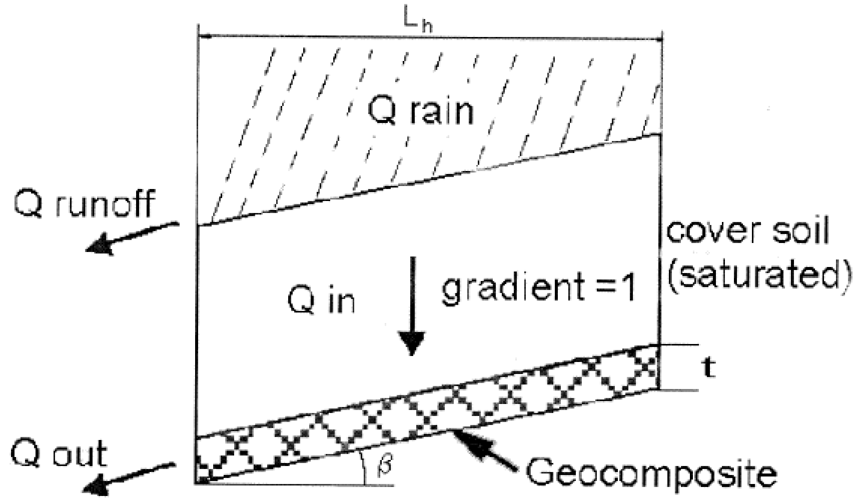
Problem Statement



The transmissivity of a drainage geocomposite must be great enough to carry all of the infiltrating flow from the soil layer(s) above. If the drainage geocomposite can not carry all the infiltrating water (very long slope, or very permeable cover soil,...); swales can be placed as shown in the above figure. The three conditions for stability are:

1. The interface shear strength of all interfaces is adequate
2. Pore water pressures do not build up and reduce the contact stress between the geomembrane and the soil. The Seepage Force Stability Calculator can be used to determine the factor of safety of a landfill cover with consideration of seepage forces
3. Landfill gas pressures beneath the liner are vented properly.The Landfill Gas Pressure Relief Calculator can be used to determine the gas transmissivity of the relief layer. The Landfill Gas Stability Calculator can be used to verify the factor of safety of a landfill cover subject to landfill gas pressure underneath a geomembrane liner.

This webpage determines the ultimate transmissivity sufficient to transmit all incoming flow within the thickness of the geocomposite; i.e. maximum head < geonet thickness; therefore seepage forces in the cover soil will be zero.



With Darcy's law:

$Q = k * i * A$

Inflow of water in the geocomposite

$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$

Outflow of water from the geocomposite at the toe of the slope

$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin \beta$

Inflow equals outflow (Factor of Safety = 1)

$Q_{in} = Q_{out}$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin \beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$

Required Data

Symbol	Name	Dimensions
L_h	Drainage pipe spacing or length of slope measured horizontally	Length
k_{veg}	Permeability of the vegetative supporting soil	Length/Time
S	The liner's slope, **S** = tan **b**	-
FS_{slope}	Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces	-

FS_d	Overall factor of safety for drainage
RF_{in}	Intrusion Reduction Factor
RF_{cr}	Creep Reduction Factor
RF_{cc}	Chemical Clogging Reduction Factor
RF_{bc}	Biological Clogging Reduction Factor

Input Values

Note: If you do not wish to perform calculations for 3 cases, please leave default data as is.

	Case 1		Case 2		Case 3	
S	5	%	5	%	5	%
L_h	30	m	30	m	30	m
k_{veg}	0.00001	cm/sec	0.00001	cm/sec	0.00001	cm/sec
FS_{slope}	1.5		1.5		1.5	

Reduction Factors and Safety Factor

	Case 1	Case 2	Case 3		Surface Water Drains
RF_{in}	1.5	1.5	1.5	[1]	1.0 - 1.2
RF_{cr}	1.4	1.4	1.4	[2]	Calculate RF_{CR}
RF_{cc}	1.2	1.2	1.2	[3]	1.0 - 1.2
RF_{bc}	1.6	1.6	1.6	[3]	1.2 - 3.5
FS_d	2	2	2	[4]	2.0 - 10.0

Calculate Transmissivity

[1] Intrusion reduction factor from 100 hour to design life. Giroud et. al (2000)
[2] Creep reduction factor from 100 hour to design life (for instance, 30 years). RF_{CR} is determined from 10,000 hour compressive creep test, extrapolated to design life, GRI-GC8 (2001). RF_{CR} is product and normal load specific.
[3] GRI-GC8
[4] FS value = 2-3. Giroud, et. al (2000)
FS value > 10 for filtration and drainage. Koerner (2001)
[5] Note: The calculated transmissivity is corresponding to the case where the seating time is 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Solution

Symbol	Name	Dimensions
gradient	Gradient	
$\theta_{ultimate}$	Ultimate Transmissivity	Length^2/Time
$\delta_{req'd}$	Minimum interface friction angle	degrees

	Case 1		Case 2		Case 3	
gradient	0.05		0.05		0.05	
$\theta_{ultimate}$	4.84E-004	m^2/s	4.84E-004	m^2/s	4.84E-004	m^2/s
$\delta_{req'd}$	4.29	degrees	4.29	degrees	4.29	degrees

Material Selection

Follow the GFR link to view our extensive database of geosynthetic materials reprinted with permission of IFAI

GEOTECHNICAL FABRICS REPORT
Online Specifiers Guide

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *

Company

Email Address *

Phone

Project Reference

Comments

*required fields

Submit Design Results

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References

"GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.

"Beyond a factor-of-safety value, i.e., the probability of failure". GRI Newsletter/Report, Vol. 15, no. 3.

"Designing with Geosynthetics". **R.M. Koerner**, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.

"Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". **J. P. Giroud**, **J. G. Zornberg** and **A. Zhao**, *Geosynthetics International*, Vol. 7, Nos 4-5.

"Lateral Drainage Design update - part 2". **G. N. Richardson**, J.P. Giroud and **A. Zhao**, *Geotechnical Fabrics Report*, March, 2002

GSE STANDARD PRODUCTS

Product Data Sheet

GSE FabriNet HF

250 mil GSE FabriNet HF geocomposites typically consist of a 250 mil GSE HyperNet core with a nonwoven geotextile fabric heat-bonded to one or both sides. The geotextile serves as a filter to protect the geonet core from clogging while the geonet provides a path for the fluids (liquids and gases). The 250 mil GSE HyperNet core is manufactured in the same manner as standard GSE HyperNet but is designed to handle higher flow requirements, as well normal loads, such as those expected in landfill expansions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE VALUE[d]		
Geocomposite			6 oz/yd^2	8 oz/yd^2	10 oz/yd^2
Product Code:			F52060060S	F52080080S	F52100100S
Transmissivity[a], m^2/sec	ASTM D 4716-00	1/540,000 ft^2	5x10^{-4}	5x10^{-4}	5x10^{-4}
Ply Adhesion, lb/in average	GRI GC-7	1/50,000 ft^2	1.0	1.0	1.0
Roll Width, ft (m)			14.5 (4.4)	14.5 (4.4)	14.5 (4.4)
Roll Length, ft (m)			230 (70.1)	190 (57.9)	180 (54.9)
Roll Area, ft^2 (m^2)			3,335 (310)	2,755 (256)	2,610 (242)
Geonet core[b]					
Transmissivity[a], m^2/sec	ASTM D 4716-00		3x10^{-3}	3x10^{-3}	3x10^{-3}
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft^2	250 (6.3)	250 (6.3)	250 (6.3)
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft^2	55 (9.6)	55 (9.6)	55 (9.6)
Carbon Black Content, %	ASTM D 1603	1/50,000 ft^2	2.0	2.0	2.0
Geotextile (prior to lamination)[b,c]					
Mass per Unit Area, oz/yd^2 (g/m^2)	ASTM D 5261	1/90,000 ft^2	6 (200)	8 (270)	10 (335)
Grab Tensile, lb (N)	ASTM D 4632	1/90,000 ft^2	170 (755)	220 (975)	260 (1,155)
Puncture Strength, lb (N)	ASTM D 4833	1/90,000 ft^2	90 (395)	120 (525)	165 (725)
AOS, US Sieve (mm)	ASTM D 4751	1/540,000 ft^2	70 (0.212)	80 (0.180)	100 (0.150)
Flow Rate, gpm/ft (l/min/m^2)	ASTM D 4491	1/540,000 ft^2	110 (4,480)	110 (4,480)	85 (3,460)
UV Resistance, % Retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70

NOTES:

- [a]Gradient of 0.1, normal load of 10,000 psf, water at 70° F between stainless steel plates for 15 minutes.
- [b]Component properties prior to lamination.
- [c]Several geotextiles are available and may be supplied as determined by GSE.
- [d]These are MARV values and are based on the cumulative results of specimens tested and as determined by GSE.

DS043 R10/22/02

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Europe/Middle East/Africa	GSE Lining Technology GmbH	Hamburg, Germany		49-40-767420	Fax: 49-40-7674233
Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097

This product data sheet is also available on our website at:

www.gseworld.com

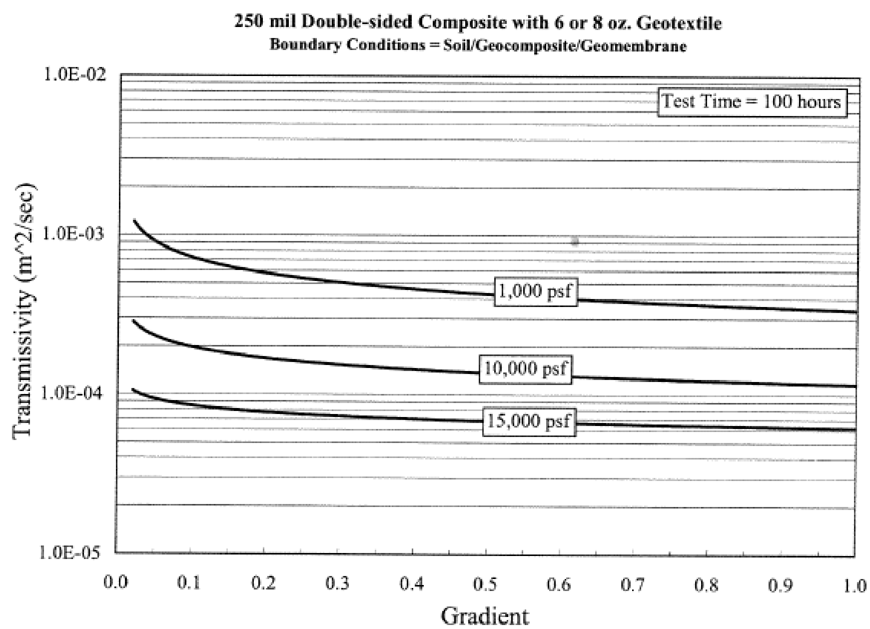

Figure A-6 100-hour transmissivity of a 250 mil biplanar geonet under soil/geocomposite/geomembrane boundary conditions.